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ABSTRACT

This paper argues that the concepts and techniques used in the development of expert systems should be expanded and applied to the field of education, particularly in the area of intelligent tutoring systems. It is noted that expert systems are a well known area of artificial intelligence and have been proven effective in well-defined topic areas. Furthermore, it is suggested that expert systems could have an impact on: (1) educational planning and decision making, particularly the use of computers to manage student records, student counselling, and special education programs; (2) teacher training and education, specifically, identifying training needs and using computer assisted instruction to teach information and skills; and (3) intelligent tutoring systems that guide students through instruction according to their individual strengths and weaknesses. It is concluded that while expert systems in education have great potential, they remain unestablished as a useful technology due to a lack of research and documentation. (9 references) (DB)

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Expert Systems in Education

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Abstract

Expert systems have shown to be very effective in narrow, highly-defined topic areas. This paper discusses why the concepts and techniques used in the development of these expert systems should be expanded and applied to the field of education, especially in the area of intelligent tutoring systems.

Expert systems can play an important role in education and have an immediate impact in areas such as, planning/decision-making, teacher training, and intelligent tutoring systems. The most dramatic effect could be in intelligent tutoring systems where students are guided through instruction based on their own strengths and weaknesses.

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Expert Systems in Education

Introduction: Artificial Intelligence and Expert Systems

The overall concept of artificial intelligence involves the creation of a man-made system which gathers data and is capable of making a recommendation based on that data. In other words, an artificial intelligence system must perform a task which, if done by a human being, requires intelligence. Intelligence is a characteristic that humans have and computers, at this time, do not. The goal of artificial intelligence researchers is to develop intelligent computers. The most well known area of artificial intelligence and possibly the area with the most advancement and practical applications is expert systems.

Definitions of expert systems are as varied as the people who write them. Some definitions refer to human experts, some to problem-solving, some to knowledge bases, and some to the way the program 'reasons.'

In general, expert systems contain the knowledge of a human expert on a very specific topic in a knowledge base and an inference engine is used to access the knowledge base to draw a conclusion similar to that of a human expert. Knowledge base and inference engine are terms specific to expert systems. A knowledge base contains questions, which are used to extract information and if-then rules that are used to draw conclusions according to the question answers. An inference engine is a computer program that captures the raw inferencing power of the human mind and applies this power to the knowledge base. If not all, nearly all expert systems in existence today use the knowledge-base principle.

Educational Uses of Expert Systems

Even though human experts are usually preferred, there are advantages to using a computerized expert system. Computer expert systems, unlike human experts, are available at one's convenience and at an affordable price. These are major determinants in the field of education. Another benefit is that most people are not as intimidated by the computerized expert system as they are by human experts. Therefore, they find themselves better able to ask questions of the computerized expert. (Bitter, Hartschuh, et. al., 1989)

There are three areas in education which expert systems can have an immediate impact: planning/decision-making, teacher training, and intelligent tutoring systems.

Planning / Decision-making

Educational planning/decision-making is a great potential use for expert systems. Information can be collected on a current student or program along with a goal, and the expert system could 'plan' intermediate steps that must occur to attain the goal. This 'plan' could be a sequential order of events along with the amount of time and money needed to achieve the goal, or a list of strategies for achieving the goal. (Haynes, Pilato and Malouf, 1987) An example would be the decision-making process of staff planning of school buildings in large school districts. The knowledge base would contain rules concerning desirable ratios of students to teachers with regard to grade, subject, class size, teacher experience, etc. The current enrollment and number and experience of teachers would be used to plan the staff not only to reassign staff but also to plan staff hiring or reduction.

Expert systems can be used for counseling students. The knowledge base would contain information regarding careers and courses vital to the student in

attaining that career. The expert system would recommend a course of study for the student so they would be prepared to enter their chosen career.

Special education is an area where numerous expert systems applications have been written. Most of these applications deal with identifying possible special education students. One such program is CLASS.LD2. CLASS.LD2 is designed to identify learning disabled (LD) students. The knowledge base contains rules and information obtained from federal and state laws, experts in the area of classifying LD students, and current literature on student assessment. (Ferrara, Prater and Baer, 1987)

CAPER (Computer-Assisted Planning and Educational Resources) is an expert system that plans sound instructional programs for individual students. This system recommends the best instructional program prior to the student's placement in a special education class. The time involved in the referral and diagnosis of possible special education students can be lengthy, and CAPER can recommend instructional options within the regular classroom setting during the evaluation process. (Haynes, Pilato and Malouf, 1987)

When an expert system is created for planning and decision-making, it should be used primarily as a second opinion. With expert systems still in their infancy, expert systems should supplement human decisions, not replace human decisions. (Haynes, Pilato and Malouf, 1987) In the future, when expert system technology has been more fully tested, expert systems could possibly be used confidently as a first source. Example: How would you feel if you were refused admission to a university based solely on the recommendation of an expert system?

Teacher Training

Expert systems have the potential to train teachers in three ways:recommend training for teachers, teach information and processes, and serve a training function.

Recommending Training for Teachers

The educational value of expert systems in training recommendations is in the ability to identify what the trainees need to know. The expert system can take into account previous training, professional goals, knowledge of teaching methods, and skill in implementing classroom instruction and then create an individualized training program for that instructor.

SNAP (Smart Needs Assessment Program) is an expert system that recommends training for regular education teachers who teach mainstreamed special education students. The expert system analyzes information on each teacher and recommends a set of training needs. SNAP is a way to eliminate the 'shotgun' approach to training, a general course designed to cover a wide variety of topics. (Haynes, Pilato and Malouf, 1987)

Teach Information and Processes

An expert system can be designed to teach a specific group a body of information, skills, and/or processes. Usually this expert system is an 'offshoot' of a planning/decision-making expert system which has been modified into a training program. (Haynes, Pilato and Malouf, 1987)

MYCIN, an expert system developed at Stanford University which can diagnose infectious diseases and recommend treatment, can be classified as a decision-making expert system. An expert system, NEOMYCIN, was subsequently developed by modifying MYCIN and used as a training tool to teach students about

diagnosing bacterial diseases. Ferrara, Prater and Baer (1987) used CLASS.LD2, an expert system used to identify LD students, as the initial expert system and modified the system to teach regular education teachers to properly classify students as LD or not LD.

The expert system used to teach information and processes can take two forms. The first would be to teach the rules contained in the knowledge base so the learner has access to the same knowledge as the expert. The second would be for the learner to work through sample consultations with examples and non-examples so the learner can discriminate between them.

Intelligent Tutoring Systems

Expert systems can be used as the basis for instructional analysis in intelligent tutor systems. The intelligent system can branch on the basis of student interaction rather than to a pre-designed set of directives. The program, therefore, may lead to changes in the instructional sequence or content based on the student responses. (Winn, 1987)

Two strategies to intelligent computer-assisted instruction (ICAI) have been developed. The strategies are the Socratic approach and the coaching approach. (Thorkildsen, et al., 1986)

The Socratic approach expects the student to infer the correct response. The ICAI program guides the student through the logic of the instructional content through a series of questions. If the student errors, the program changes the order of questioning to help the student correct any misunderstandings. (Thorkildsen, et al., 1986)

ICAI programs which utilize the Socratic approach are SCHOLAR (Carbonell, 1970) and WHY (Stevens, Collins and Goldin, 1978). The SCHOLAR program is a

South American geography tutor. The WHY program is a tutorial relating rainfall and other physical elements such as, moisture, wind, and warm air streams.

The coaching approach allows the student to explore a variety of problem-solving methods. As problems are presented to the student, an intelligent tutoring component analyzes the responses and suggests alternate methods and why the alternate method was chosen. (Thorkildsen, et al., 1986)

A program which uses the coaching approach is WEST (Burton and Brown, 1976). WEST coaches students to apply efficient ways to solve problems in addition, subtraction, multiplication, and division. The computer coach in WEST offers criticisms and suggests to the student ways to improve their arithmetic problem-solving.

The construction of deductive proofs in a traditional Geometry class is a major stumbling block for many high school students. The Geometry Proof Tutor (GPTutor) is a computer-based "artificially intelligent" tutoring system which is designed to give one-on-one instruction and coach the student during proof construction. The expert system within GPTutor embodies the necessary knowledge for successfully solving the proofs which are presented. Therefore, the student is able to work at his or her own pace without the strain of peer pressure. The results of using GPTutor have shown a favorable impact on both student ability and attitude. (Wertheimer, 1990)

Conclusion

Expert system technology in education has great potential. There is an increasing interest in expert systems, and with the advent of the microcomputer, availability of expert system software and affordable costs, education has started to explore possible uses.

The performance record of expert systems has not yet been established. Research needs to continually explore the accuracy of knowledge bases and the adequacy of expert system consultations. Until this research establishes a successful record of accomplishment, expert systems will be limited to second opinion or decision-making support only. The documentation of successful research is essential before expert systems will be readily available to the educational community.

To date, expert systems have demonstrated expertise in highly defined, narrow areas of knowledge. The area of medicine has been an excellent area for expert system development because of the ability to narrow down the field to highly defined subject areas. There is no reason why the same concepts and techniques cannot be expanded and applied to education leading to expert systems becoming an important tool for educators.

Intelligent computer-assisted instruction (ICAI) is the area where expert systems can have the most dramatic effect on education. ICAI programs compare the learning task to the student response with attention given to the things the pupil does wrong, forgets to do, does unnecessarily, and does in the wrong order. This 'automated tutor' can then give direction to the student's learning based on the student's strengths and weaknesses. Working with these 'automated tutors' or ICAI programs instead of using traditional teaching methods, should permit the student to learn more in a shorter period of time.

Expert system technology is constantly breaking new ground and applications are allowing people to receive expert direction, make difficult decisions, and perform complex tasks. This 'forward advancement' in expert systems is one that holds great promise for educators.

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